Organizing a High Accuracy GIS Prototype Using Diverse Existing Elements

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Geographic Information Systems (GIS) and spatial data applications at the Minnesota Department of Transportation (Mn/DOT) are numerous and diverse. Like most large organizations, nearly every application and data set at Mn/DOT has been developed independently in an isolated environment. In the rapidly developing world of network accessibility and cross-platform applications, the need for a more accessible GIS has been recognized. The Metro Division of Mn/DOT has initiated a pilot project designed to study the feasibility of implementing a high accuracy GIS that is accessible and usable by everyone in the division. The Metro Division manages program delivery and operations for the seven-county (Twin Cities) area of the Minnesota Department of Transportation. The pilot is also designed to perform a cost-benefit analysis on collecting high accuracy basemap information. The body of this pilot focuses on the development of an implementation plan. Project scoping and methodologies are crucial in this endeavor. As the project evolves through the phases of conceptualizing data items and applications, the prototype will introduce logical object, data, and application models in a dimension that is new to Mn/DOT's Metro Division. There are many technical issues to manage as well. Several prominent GIS and data technologies will be explored. This project manifests a fascinating blend of business procedures, technical skill, and communication transactions. As each of these components becomes more important in Transportation GIS, it will be demonstrated that it is in fact possible to integrate all of these elements successfully and push the transportation industry into the next generation of information systems. Key words: enterprise, application, implementation, process, high-resolution.

INTRODUCTION

Geographic Information Systems (GIS) and spatial data applications at the Minnesota Department of Transportation (Mn/DOT) are numerous and diverse. Like most large organizations, nearly every application and data set at Mn/DOT has been developed independently in an isolated environment. In the rapidly developing world of network accessibility and cross-platform applications, the need for a more accessible GIS has been recognized.

Mn/Dot's Metro Division manages program delivery and operations for the seven-county (Twin Cities) area of the Minnesota Department of Transportation. The entire department employs about 5,000 people, and the Metro Division is about one third of the employee total.

The Metro Division of Mn/DOT has initiated a pilot project designed to study the feasibility of implementing a high accuracy GIS that will be accessible and usable by everyone in the division. Proposal and initiation of the pilot are a result of the increasing need for higher resolution and better communication in GIS mapping. There is a call for data sharing to become more common and easy to use in daily transactions. A two-year period has been established to develop the prototype and the metro-wide implementation plan.

The resulting prototype will make GIS data and applications centrally available with varying levels of access, and focus on creating a one-stop basemap that is created and maintained with the highest possible resolution. Since more and more data in the organization are being created with higher accuracy standards, the prototype GIS will provide centimeter accuracy for centerline, milepost, and section corner data, and sub-meter accuracy for all other data (except where greater accuracy is required on a per-project basis). Methods will also be developed to associate data relationships within Mn/DOT's systems of managing spatial data through a common database. The project identifies supplementary non-spatial and external data links that are usable in a GIS.

MISSION

The High Accuracy GIS Prototype will introduce a GIS model to Mn/DOT Information Systems that is easily accessible and usable across platforms and envelops the geo-spatial accuracy needed for business functions within the Metro Division.

GOALS

1. Model a GIS that interfaces existing and future Mn/DOT data
2. Evaluate accuracy solutions for basemap products
3. Examine efficiency enhancements for Metro Division databases
4. Develop an Implementation plan.

PURPOSE

Implementation and study of this prototype enables Mn/DOT to move further into the cutting edge of high technology with new tools and methodologies that enhance the existing system and better serve the business needs of the organization.

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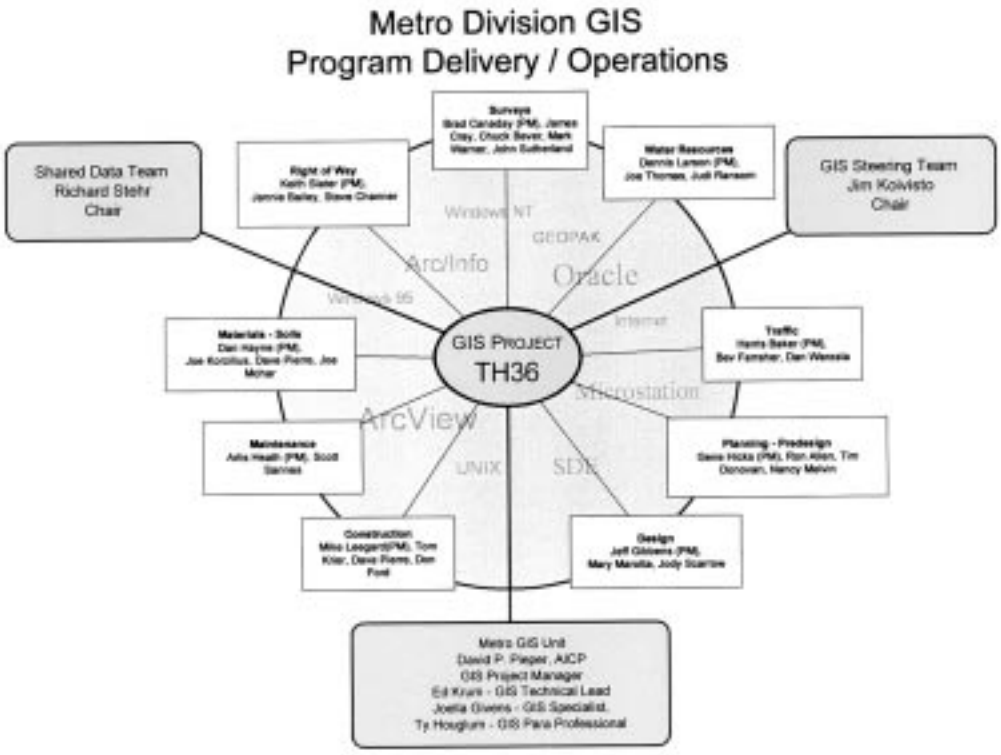

FIGURE 1 Organizational relationship model.

HISTORY

Historically, similar projects at Mn/DOT have not met implementation, or at best, were only partially implemented. A closer look at these projects shows that they might have failed because too much area (geographic and business) was covered in the initial plan, the scope of the project was not laid out clearly enough, or the technology was not yet in place to build an effective system. Communication with upper management also became a problem when attempting to secure funding or support necessary organizational changes.

In an effort to procure success of the current project, predecessors' "lessons learned" are being examined closely. A fundamental consideration in this effort is to limit the geographic extent during the period of study, but set up metrics to measure the scalability of implementing the plan across the metro area. Another extremely important factor is to explicitly define the number the components of the prototype well before modeling or application development begins. Extensive measures will be made to ensure quality and integrity of the proposed system and that there is a business need that warrants every prototype application that is created. Effective communication will certainly be a primary objective with all levels of Mn/DOT personnel.

In most cases, the technical activities required to carry out such a project in the past were not able to be coordinated within the organization. The type of data, systems, and applications being used were not mature enough to be used in this way, and technical flaws (however inconsistent or unpredictable) were considered normal. Now we have network accessibility and the ability to easily cross platforms in applications that never existed before. For example, data communication can be made between Windows and UNIX, GIS and CADD, and to the world via the Internet.

In addition to rapid technological advancements, methodologies and process management techniques are greatly improved in the GIS arena. As these higher technologies become more mature and better known to the GIS community and organizations such as Mn/DOT, the processes for developing them benefits from lessons of the past.

PROJECT TEAM AND RESOURCES

The Metro Division has organized a team lead by a core staff of three people to design the prototype models and applications, and devise the implementation plan (Figure 1). There is a project manager, technical lead, and project specialist. Student workers and graduate engineers are also working on the project.

The staff needs to reach out to many groups within Mn/DOT to design and create the prototype. A significant effort has been made with each of nine functional groups to ensure that the business needs of the metro division are met in this prototype. Functional group is the term used by Mn/DOT to describe a team or group of teams that has a specific purpose to the overall workings of the organization. For example, the Right-of-Way Group manages real estate for the organization. Within each functional group, three people are assigned to interface with the GIS prototype, each with a specific role. The Project Manager role is the point-of-contact for the

group, the Technical Expert is the person who is most familiar with the group's data, and the Process Expert is responsible for identifying and communicating the business needs of the group.

The relationship of the TH36 project team with other significant factions at the Metro Division is depicted in Figure 1.

STUDY AREA DESCRIPTION

The study area for the model is the full corridor of Minnesota State Trunk Highway 36 (TH36). This highway is of special interest because of its wide variety of characteristics, including: entrance/exit ramps, traffic control signals, regulated entrance signals, rural and urban design, crossing of county and municipal boundaries, future development plans, and current availability of data.

PROCEDURES

Conceptualization

First efforts to define and tame the initial concept of the prototype were challenging. After the preliminary project goals were identified the project team was assembled. The next major task was to build consensus and identify key players in Mn/DOT Metro Division functional groups. Then the team began to build relationships with Mn/DOT contacts outside of the Metro Division, and disclose relationships with individuals and organizations outside of Mn/DOT who would have either input or interest in the efforts of the project.

Scope

After initial meetings and getting a feel for what the requirements for the project were, the team began to understand what was possible to do in two years and what was not. Since many useful ideas emerged that were clearly out of scope, a pool was created to collect ideas to be proposed as future projects (refer to the pool in Figure 2). Resources for the project were identified which included the creation of the core GIS staff, existing Mn/DOT staff and resources, and consultants.

Technologies that are applied in the prototype include networks, Windows (NT and 95), Microstation, ESRI products (corporate standard for GIS), Oracle (corporate database standard), MS Access (and other database engines), GEOPAK, Internet (WWW) Technology, and Spatial Database engines (SDE). Many other proprietary applications and data storage systems are currently in use.

The scope of the project is bound by the constraints of three major elements: construction of a GIS basemap, database design and architecture, and applications to demonstrate the prototype.

Basemap

High Accuracy Solutions will be examined for a metro-area basemap that has greater resolution than existing sources. The current Mn/DOT basemap being used for general business analysis is estimated to be accurate within 40 feet, with a resolution of 1:24,000. This resolution does not meet the business needs of functional groups that collect data with precision survey and GPS instruments. Many survey-quality maps exist in the CADD environment, but have limited geographic extents and are valid only through the life cycle of particular construction projects.

Through the use of new technologies in GIS mapping, the basemap for the prototype will strive for centimeter accuracy for centerline, milepost, and section corner data, and sub-meter accuracy for all other data that warrant a need for high accuracy. This will be achieved through the use of photogrammetics based on low level flights (1500 feet), video surveying from van and helicopter viewpoints, laser ranging, and Global Positioning Systems (GPS). Existing data derived from traditional surveying methods will also be utilized where appropriate.

Database

Modeling and building the objects and architecture of the Metro Division database are the most involved tasks that the project team faces. Most of the data sets that will be used in conjunction with the high accuracy GIS basemap already exist, but are held in a variety of formats. Many of the data sets are stored in isolated and proprietary formats. Some are generously distributed, but are engineered with redundant (de-normalized) and irregular structures. The feasibility of integrating a homogenous database structure into the prototype will be evaluated by incorporating the data object model in third normal form. More simply, all data for the prototype will be placed into one database - Oracle, and each table will be reduced to its simplest form. This will provide flexibility for query and transaction management of the data as well as provide a template for future attempts by Mn/DOT functions to enhance the efficiency of data sharing.

Applications

In our initial assessment it is clear that a single application will not meet the needs of every user. There are many users who will only have simple queries to the database. They should not be required to learn complicated interfaces such as ArcView, Arc/Info, or Oracle. Others will need to be able to manipulate fine details in the database. Figure 2 illustrates this concept.

The prototype application will be a proof-of-concept that business needs can be met by combining a homogeneous database structure with a high accuracy GIS basemap. A suite of applets will be employed to encompass the solutions to many problems. The aspects of managing different types of data (such as point, line, and polygon features) will each need to be sampled so other data elements can be incorporated into the model upon implementation. An array of data access will also need to be considered, so simple functions will be constructed to interact with data at many levels. These levels (referred to in Figure 2) correspond with applications that range from simple queries to full authority over data.

Project Plan

The project plan is based on a template supported by Mn/DOT's Office of Information Resource Management. Stages of the project unfold from conceptual to logical, and finally physical design and

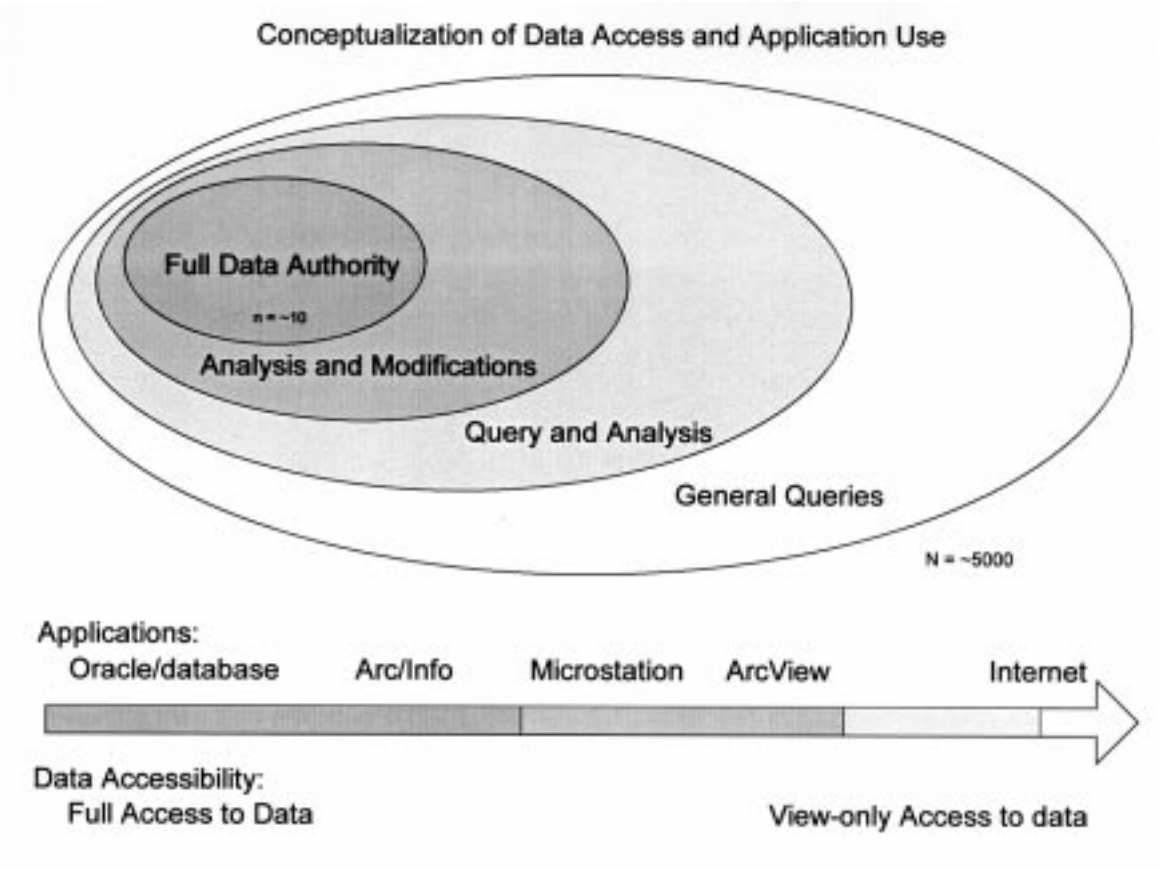

FIGURE 2 Database access and application model.

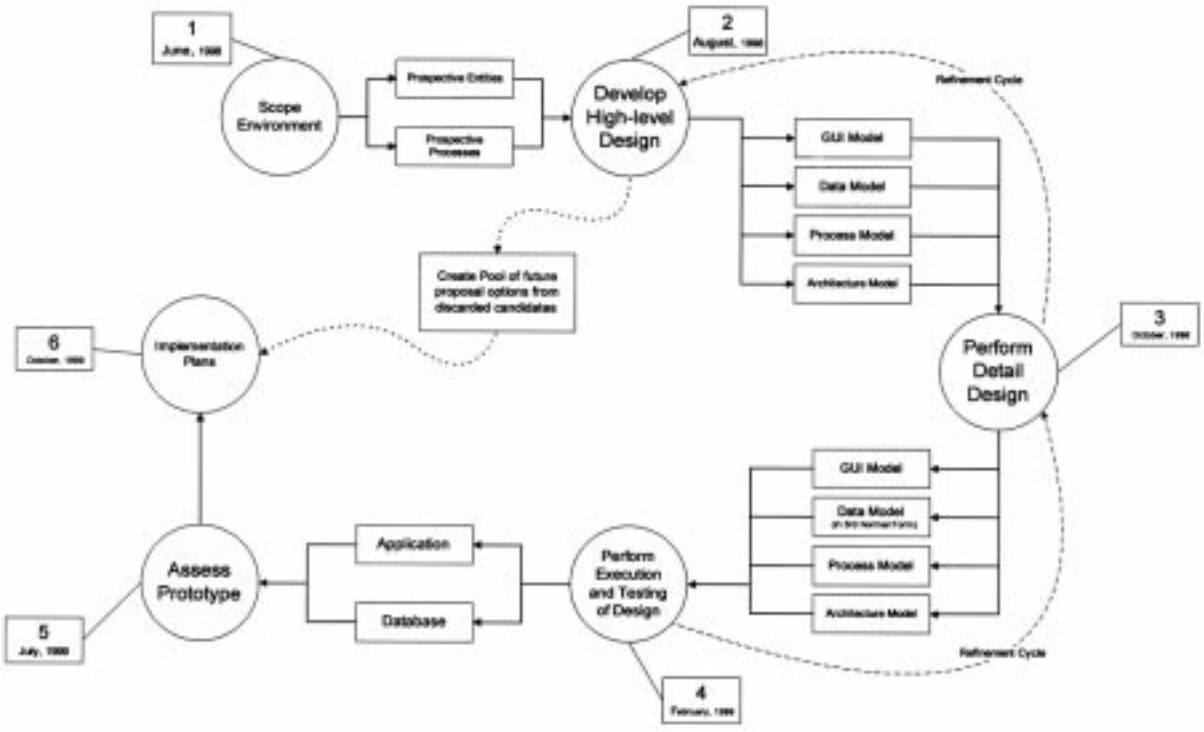

FIGURE 3 Project plan model.

construction of graphical user interfaces (GUI's), applications, databases, and architectures that will be the essence of the prototype. Final stages of the process will include user and stress testing of the prototype. When the quality and integrity of the prototype can be assured, an implementation plan will be presented with supporting demonstrations. Quality will be monitored throughout the process. The key elements of the plan and schedule are modeled in Figure 3.

ANTICIPATED HURDLES AND ISSUES

The first approach to a participating group or individual is very critical. People are used to doing work that gets a specific job done or meets their business needs only. Integrating into the bigger system is a lot of work. This is a technical challenge, and it also requires people to overcome the constraints of keeping data in the local arena and moving into a more global way of thinking and communicating. While Mn/DOT's business needs must be addressed as a whole, the functional groups will need to remain empowered within their own areas of expertise.

The issues of stewardship agreements, conflicting data needs, software licensing, data access, missing and sensitive data, and resource allocations will need to be scrutinized. These problems will be particularly pertinent when facing the complexity and scalability of the model.

The team is determined that a positive atmosphere of change can be promoted by anticipating these hurdles. The prototype can foster cooperation and trust by effectively demonstrating the benefits of interactive data sharing across functional groups.

IMPLEMENTATION PLAN

Working towards completion of the TH36 model, an implementation plan will be created for the Metro Division, which may or may not follow the prototype. The effective plan will engage changes from the prototype as well as successful components. While the models for applications, databases, architectures, and basemaps are not expected to be "throw-away" products, the core product of the project, the implementation plan, will specifically address how the high accuracy data sharing concept can be realized when promoting the scale to a metro-wide universe.

Core elements of the implementation plan are cost benefit analysis, time frame for Metro implementation, cost and resource estimates, process model, hardware/software needs, system and database administration, staffing issues, maintenance options, and others which are revealed during the prototyping process. Provisions will be made for enhancements to the methodologies as technologies and business needs change.

The plan will be designed as a multi-purpose tool that can be broken down into many parts. As a whole, it will be directed towards implementing an accessible, high-accuracy GIS in the Metro Division of Mn/DOT. Modules can be broken out of the plan that can be shared with others, including other Mn/DOT offices, other DOT's, and facilities management organizations. Reusable code from applications will be identified and documented. A "Lessons Learned" section will be quite conspicuous. Some of the "pooled" ideas that fall outside of the project scope will spawn proposals for future projects, and a summary of those proposals will be included.

CONCLUSION

The TH36 High Accuracy GIS Prototype manifests a fascinating blend of business procedures, technical skill, and communication transactions. As each of these components becomes more important in Transportation GIS, we would like to show that it is, in fact, possible to integrate all of these elements successfully and push the transportation industry into the next generation of information systems.